Q. STATE YOUR NAME AND BUSINESS ADDRESS.

A. Susan Calder Shaw

Washington Department of Natural Resources, Forest Practices Division, 1111 Washington St. SE, P.O. Box 47012, Olympia, WA. 98504-7012

Q. *Where are you employed and what is your job title?*

A. I am employed in the Forest Practices Division, Washington Department of Natural Resources (WDNR). My work station is located in Carson, Washington (address: WDNR, Forest Practices, 211 Hemlock Rd., Carson, WA. 98610). My job title is Natural Resource Scientist 2 (Geomorphologist). I am not assigned to a WDNR region office; rather, I work on state-wide issues for the Forest Practices Division, and I respond to work requests from all region offices.

Q. What is your educational background?

A. My educational background is as follows:

(1) A.B. Degree with High Honors Oberlin College, Oberlin, Ohio

Geology Degree received: 1981

(2) M.S. Degree University of Washington, Seattle

Geomorphology and Sediment-Transport Mechanics

Degree received: 1987

(3) Ph.D. Degree University of Washington, Seattle

Geomorphology and Sediment-Transport Mechanics

Degree received: 1994

Q. Summarize your professional experience.

A. My professional experience includes the following:

1998-present Geomorphologist, WDNR, Forest Practices Division, Watershed Analysis Program, Olympia, WA.

Experience: Principal investigator on a project funded by the Timber/Fish/Wildlife Agreement[1], WDNR, and Washington Forest Protection Association to test and refine currently available, predictive slope-stability models (i.e., quantitative models developed for the Geographic Information System (GIS) computer platform), for application to Washington forest practices. Participate in conducting channel and mass-wasting module assessments for regulatory watershed analysis. Consult with field staff on forest-practices issues (e.g., mass wasting and channel processes) in all regions. Participate in policy development and implementation regarding watershed-analysis and scientific-technical issues. Am involved in litigation for WDNR's Habitat Conservation Plan (HCP). Teach channel-conditions module lectures and laboratory for WDNR's watershed-analysis certification program.

1996-1998 Acting Watershed Analysis Program Manager, WDNR, Forest Practices Division, Olympia, WA. (alternating with Nancy Sturhan)

Experience: Managed the Washington Forest Practices Board watershed-analysis program, supervised scientific and technical staff, coordinated program development with T/F/W caucuses, coordinated and conducted watershed-analysis training. Gave several invited lectures on mass wasting, watershed analysis, and fluvial geomorphology.

Geomorphologist, WDNR, Forest Practices Division, Watershed Analysis Program, Olympia.

See summary of current experience, as it also applies here. Also was a primary author of the WDNR's HCP (i.e., aquatic conservation strategies).

1991-1994 Geomorphologist, WDNR, state lands program, Olympic Region, Forks, WA.

Experience: Served as the region's consultant to field staff on geologic and geomorphologic issues, including mass wasting and channel processes. Provided field input on timber-sale designs and road-construction plans. One of several authors of Clallam Bay Landscape Plan for state-managed lands. Co-authored a GIS-based slope stability model for shallow landslides, for management applications (with David Johnson, WDNR, Olympic Region). Chaired or participated in several interagency committees on resource issues pertaining to timberlands on the Olympic Peninsula.

1984-1991 Graduate Research Assistant, University of Washington, Seattle, WA.

Experience: Conducted field, laboratory, and theoretical research on sediment-transport mechanics in river and wind environments. Participated in federal grant writing, authored papers, and presented research results at national/international conferences.

Resource Management Technician, North Cascades National Park, Sedro Woolley, WA.

Experience: Directed a pilot soils rehabilitation and revegetation program for the National Park Service. Worked on slope stabilization and surface-mining reclamation projects.

1981-1983 Staff Research Assistant, Arizona Geological Survey, Tucson, AZ.

Experience: Assisted with three projects funded by the U.S. Bureau of Mines (geological and historical assessment of mines and prospects in Arizona), U.S. Bureau of Land Management (interpretation of geochemical and geostructural data for assessing mineral potential in proposed wilderness areas), and U.S. Geological Survey (evaluation of hydrogeology and subsurface geology in western Arizona, for use in locating potential nuclear waste repositories).

1980-1981 Research Assistant, Oberlin College, Oberlin, OH.

Experience: Conducted paleontologic and paleoenvironmental analysis of Precambrian-age rocks from the Arctic Ocean region.

1980-1983 Resource Management Technician, North Cascades National Park, Sedro Woolley, WA. (Summer seasonal.)

Experience: See 1983-1984 job experience.

______ My primary professional and academic training includes river and hillslope geomorphology (i.e., study of earth-surface physical processes), mechanics of sediment transport and sediment-transporting flows, environmental geology, bedload-transport theory and field evaluation, slope stability analysis, and surface hydrology. I also have professional training and experience in soil rehabilitation, channel and riparian restoration, and remote sensing.

Q. *What is the subject matter of your testimony?*

A. I am providing testimony on issues related to:

(1) mass wasting (i.e., landslides) and slope stability; and,

(2) proposed stream crossings and potential physical impacts to streams and floodplains of pipeline construction and operation.

Gary Sprague, Washington Department of Fish and Wildlife (WDFW) and John Mumford, WDNR, are addressing the potential biological impacts to streams of pipeline construction and operation.

MASS WASTING

Q. Do the Washington Forest Practices Act and associated regulations address the issues of landslides and mass wasting?

A. Yes. See specific citations of applicable regulations (WACs) from the Washington Forest Practices Act (RCW 76.09), provided later in this written testimony..

Q. Define each of those terms as they are used in the Washington Forest Practices Act and related documents

A. The terms "mass wasting" and "landslide" commonly are used interchangeably in reference to the downslope movement of a portion of the land surface, under the force of gravity. As defined in the Washington Forest Practices Board manual for conducting watershed analyses (under Chapter 222-22 WAC; WFPB, 1997), mass wasting is:

> "A general term for the dislodgement and downslope transport of soil and rock under the direct application of gravitational stress (i.e., without major action of water, wind, or ice); mass movement." (WFPB, 1997, Glossary, p. 3).

Similarly, a landslide is defined as:

> "Any mass-movement process characterized by downslope transport of soil and rock, under gravitational stress, by sliding over a discrete failure surface; or [the term can also refer to] the resultant landform [created by mass movement]". (WFPB, 1997, Glossary, p. 3).

Mass wasting is differentiated from other forms of soil movement by the fact that a mass or unit of the ground surface is involved, rather than individual movement of discrete particles. For the purposes of Forest Practices regulations (e.g., see WFPB, 1997), the latter (i.e., soil creep or surface ravel) generally are referred to as "surface erosion". The watershed-analysis manual (WFPB, 1997, Appendix A.) identifies four main categories of mass wasting typically found in Washington; they include:

(1) *Rock falls or rock avalanches*;

(2) *Shallow, rapid landslides*. Otherwise known as debris avalanches, these landslides are rapidly occurring failures of the soil mantle, typically to a depth of about 10 feet.   Shallow, rapid landslides often develop into debris flows when sliding materials enter stream channels with flowing water;

(3) *Deep-seated failures.* Otherwise known as earthflows, these landslides typically move sporadically or continuously over a period of days to centuries, often involving all layers between the soil surface and underlying bedrock. They commonly incorporate large areas (i.e., acres to hundreds of acres) and are partially controlled by the amount and timing of water percolating into the groundwater table; and,

(4) *Debris torrents* (i.e., debris flows and dam-break floods). Debris flows are formed when landslide materials enter flowing water and are transported downstream as a fluidized mass. Dam-break floods are created when

landslides or avalanches temporarily block water flow through channels; the debris dam catastrophically fails when water backs up and over-tops the dam.

Mass wasting can be triggered by natural and man-caused disturbances, or some combination of the two, and it can recur at a particular site depending on the timing, frequency, and duration of triggering events (e.g., see WFPB, 1997; Appendix A. Mass Wasting Module). Triggering factors include:

(1) slope hydrology (i.e., changes in surface- and ground- water regimes, for example, during storm events);

(2) soil properties (e.g., changes in soil depth, cohesion);

(3) geologic structures (e.g., bedrock structure and composition, movement along bedrock faults);

(4) seismic events (e.g., earthquakes); and,

(5) vegetation composition and structure (e.g., loss of root strength, changes in vegetation type).

Timber-harvest and road-building activities that trigger mass wasting include altering slope hydrology (e.g., by concentrating surface water in slide-prone areas), compacting or removing soil layers, and modifying vegetation cover (e.g., by harvest, fire, road and landing construction) such that critical root strength is lost (e.g., see Selby, 1982; Sidle et al., 1985; WFPB, 1997). In any landslide inventory performed as part of a

Forest Practices regulatory function (e.g., geotechnical consultation with foresters, T/F/W interdisciplinary team review, regulatory watershed analysis), the existing and potential triggering mechanisms usually are identified and described.

Note: Hereafter in this written testimony, I refer to landslides, mass wasting, and mass movement collectively as "mass wasting".

Q. *How do the forest practices act and associated regulations address mass wasting?*

A. WAC 222-16-050 (WFPB Manual, 1995) states that an application to conduct forest practices requires an environmental checklist, in compliance with the State Environmental Policy Act (SEPA) and SEPA guidelines, when:

(1) the applicant proposes to construct *roads, landings, rock quarries, gravel pits, borrow pits and spoil disposal sites* on slide-prone (i.e., mass-wasting) areas in a watershed administrative unit (WAU) that has not undergone a watershed analysis under chapter 222-22 WAC (see WAC 222-16-050(1)(d)). This WAC applies when a slide-prone area occurs on an uninterrupted (i.e., no substantial breaks in gradient) slope above Type 1 through 5 Waters, Type A or Type B Wetlands, or capital improvements of the state or its political subdivisions "where there is potential for a substantial debris flow or mass failure to cause significant impact to public resources" (WAC 222-16-050(1)(d)); and,

(2) the applicant proposes to *harvest timber* on slide-prone areas in a WAU that

has not undergone a watershed analysis under chapter 222-22 WAC, where such areas contain soils, geologic structures, and local hydrology indicating that forest-canopy removal has the potential for increasing slope instability (see WAC 222-16-050(1)(e)). This WAC applies when a slide-prone area occurs on an uninterrupted slope above Type 1 through 5 Waters, Type A or Type B Wetlands, or capital improvements of the state or its political subdivisions "where there is potential for a substantial debris flow or mass failure to cause significant impact to public resources" (WAC 222-16-050(1)(e)).

Applications requiring a SEPA checklist are categorized as Class IV-Special.

"Slide-prone" areas, as referenced in (1) and (2) above, are determined by WDNR staff using "available soils information, or from evidence of geologically recent slumps or slides, or where the natural slope exceeds the angle of repose for the particular soil types present, or where springs or seeps may indicate unstable conditions are present in or above the construction site" (WAC 222-24-020(6)). This WAC also states that: "Where feasible, do not locate roads on excessively steep or unstable slopes or known slide prone areas as determined by the department" (WAC 222-24-020(6)).

Prior to approval of the forest-practices application, in a WAU that has not undergone a watershed analysis per chapter 222-22 WAC, proposals for road construction or timber harvest in mass-wasting areas may be restricted or conditioned by the Forest Practices Forester and/or responsible WDNR official. Conditioning is based on field information or other evidence that such activity might impact public resources. Typical application conditions include: (1) no timber harvest; (2) partial timber harvest; (3) seasonal restrictions on harvest or road-construction activities; (4) limitations on the type of harvest or road-building methods and equipment; (5) no road construction; and (6) seasonal restrictions on road use.

In areas for which watershed analyses have been performed per chapter 222-22 WAC, management prescriptions regulate forest activities in mass-wasting sites with existing or potential likelihood of delivering materials to waters of the state in which public resources might be adversely impacted. See written testimony of Nancy Sturhan (WDNR) regarding the purpose, methods, scientific analysis, and prescription-writing procedures of the regulatory watershed-analysis process. Prescriptions that address mass-wasting concerns must meet or exceed the levels of protection afforded by standard (i.e., non-watershed-analysis) rules; WAC 222-22-010(4) states: "... the rules in this chapter are in addition to, and do not take the place of, the other forest practices rules in this Title 222 WAC". The intent of prescriptions is to allow only those management activities that would minimize or prevent material delivery from mass-wasting sites to areas in which public resources (i.e., fish habitat, water quality, and capitol improvements of the state) are, or might be, adversely impacted by debris deposition (WAC 222-22-070(3)).

Q. Were mass-wasting inventories and assessments completed for the proposed pipeline *route? Does the route cross any areas of mass wasting?*

A. Yes, a mass-wasting inventory and general assessment of mass-wasting characteristics are present in OPL Application 96-1 (OPL, 1998; pp. 2.15-22 to 2.15-30 and Tables 2.15-4 and 2.15-5). According to the application, mass-wasting sites were identified "for portions of the proposed pipeline route" (p. 2.15-23, para. 1), although how those portions of the pipeline route were chosen for investigation is not discussed. The application also states that a preliminary screen for mass-wasting features was performed for these segments of the proposed route, using remote techniques (e.g., maps and photos) and field reconnaissance of selected sites to "determine the need for protective measures" (OPL, 1998; p. 2.15-24, para. 1).

Yes, the proposed pipeline route crosses numerous identified mass-wasting sites. The pipeline application (Olympic Pipe Line Company (OPL), 1998) indicates that the proposed pipeline crosses at least 51 mass-wasting sites with a moderate to high potential for mass wasting (see Table 2.15-4 of the pipeline application).

In my opinion, the application gives an adequate definition of the scientific criteria used to assign low, moderate, and high ratings to mass-wasting sites (OPL, 1998, 2.15-26 to 2.15.-27). However, the ratings applied to some sites contradict information obtained from the field. For example, a deep-seated failure at Griffin Creek (OPL, 1998, Table 2.15-5, reference to map-atlas page 12 (Dames & Moore, 1998)) is rated by this inventory as having a low hazard potential for mass wasting. This deep-seated failure, however, is an active landslide (see Mass-Wasting Map Unit 7, Appendix A, Weyerhaeuser Co., 1995) which, according to the rating scheme presented on page 2.15-26 of the application, would give this site a high hazard-potential rating. I believe that the rating assigned to this site, therefore, is incorrect.

Another example includes a series of potential road- and landing- related failure sites upslope of the proposed pipeline corridor, which have a high potential for releasing debris flows that could impact the pipeline (sections 31, 32, and 33 (T23N, R9E), sections 3, 4, and 12 (T22N, R9E), sections 16, 17, 18, 21, 22 (T22N, R10E), and section 17 (T22N, R11E); see map atlas pp. 18-24 (Dames & Moore, 1998)). These high-hazard sites are not included in the pipeline landslide inventory (OPL, 1998, Table 2.15-5).

Therefore, it appears that the hazard ratings supplied in the pipeline landslide inventory (OPL, 1998, Table 2.15-5) have not been verified adequately in the field, nor have existing landslide inventories (e.g., Weyerhaeuser Co., 1993, 1995) been cited. In addition, the landslide inventory appears to be incomplete, since sites with a high potential for mass wasting have been omitted. See discussion on both of these topics later in this testimony.

Q. Does the pipeline application include a complete inventory of mass-wasting sites that have a potential for material delivery? If incomplete, what would be required by the WDNR if this were a forest-practices application?

A. In my opinion, the mass-wasting inventory included in the application is incomplete. My reasons are:

(1) The inventory does not include several potential mass-wasting sites with a potential for material delivery to the pipeline corridor and to waters of the state. Fieldwork by WDNR staff (see written testimony of David Weiss, WDNR, South Puget Sound Region) indicates that several potential mass-wasting sites are not referenced on the mass-wasting inventory included in the application. A number of these sites have the potential for releasing debris flows that would erode tributary channels cutting across the pipeline corridor, possibly damaging or breaking a buried pipeline. These sites are discussed in greater detail later in this testimony and in written testimony provided by David Weiss (WDNR).

(2) As mentioned in the preceding question, only portions of the proposed pipeline route were analyzed (OPL, 1998; p. 2.15-23, para. 1).

(3) As mentioned in the preceding question, the inventory was compiled largely using remote techniques, with a subset of sites evaluated in the field (OPL, 1998; p. 2.15-23, para. 2).

In my opinion, items (1), (2), and (3) above indicate that the analysis is inadequate for basing decisions regarding pipeline location, construction, operation, and maintenance. The primary reason for this conclusion is that the potential exists for misidentifying or mislocating areas of slope instability. Building a pipeline corridor through unstable ground could result in activating or reactivating a landslide, which then could damage the pipeline and deliver sediment to waters of the state that support vulnerable public resources.

If this application were submitted to the WDNR, Forest Practices, for approval of forest-practices activities associated with the pipeline, it would not be approved until additional information was supplied regarding the comprehensiveness of this inventory and the rationale used to select sample areas for mass-wasting analysis in the field (see later comments in this testimony regarding what elements would be required of a forest-practices application). For the reasons stated above (i.e., the potential for disturbing unstable ground and impacting public resources), it is important to know the exact location of all unstable ground, so that the potential impacts of the proposed operation on the physical integrity of these sites can be evaluated by those approving the application. In addition, it is important to understand the methods used to identify unstable ground, because some methods (e.g., using soils maps or remotely sensed information) are less accurate than others (e.g., using existing, field-derived landslide inventories or conducting field analyses) (see Shaw and Vaugeois, in preparation).

In addition, the WDNR would require a field geotechnical analysis of each site with a moderate to high potential for new or recurring failure would be required, *prior* to approving any timber-removal, road-building, or right-of-way activities (RCW 76.09.060(1); see further discussion later in this testimony). The reason is that the

WDNR approval process is based on knowing exactly the potential for slope failure and resource impact, as well as the proposed operation, so that the ability of the applicant(s) to operate without adversely impacting public resources can be judged knowledgeably. This would include delineating the boundaries of mass-wasting areas and flagging the area of proposed operation on the ground, so that the Forest Practices Forester (i.e., WDNR's field regulator) could accurately evaluate the proposal in the field. Given that the company proposes to conduct field geotechnical analyses *following* approval of the application and has not provided site-specific work plans, the pipeline application would not be acceptable to WDNR in its current form.

If a mass-wasting inventory exists that is more complete than Table 2.15-4 (OPL, 1998), I believe that it should be included in the application. Otherwise, it is not possible to fully evaluate the potential impacts of mass-wasting processes on pipeline integrity and public resources, nor is it possible to assess the full potential impacts of pipeline construction and maintenance on promoting mass-wasting events.

Q. Does the proposed pipeline route cross mass-wasting areas identified in regulatory watershed analyses? If so, does the application address regulatory prescriptions in place for protecting public resources from mass-wasting impacts?

A. Yes, the proposed route crosses mass-wasting sites described in watershed analyses. The proposed route crosses the following sites for which mass-wasting prescriptions have been written (or currently are being drafted) as part of the watershed-analysis process:

(1) Tolt WAU - the proposed route crosses two landslides identified in the watershed-analysis process, which might be the same as those referenced in the pipeline mass-wasting inventory, occurring northwest of Stream Crossing 26 and southwest of 27 (OPL, 1998; Table 2.15-4; see Dames & Moore, 1998). Regulatory prescriptions, in place since 1993, are not mentioned in the application.

(2) Griffin-Tokul WAU - the proposed route crosses at least two existing landslide sites with direct material delivery to a Type 1 Water[2] with vulnerable fish habitat. These sites also are shown on the inventory in the pipeline application. However, regulatory prescriptions, in place since 1995, are not mentioned in the application.

(3) Keechelus Lake and Mosquito Creek WAUs - the proposed route crosses three areas mapped as having moderate to high potential for material delivery to public resources (i.e., fish habitat, water quality, and public works including the John Wayne Trail and Interstate 90). Only one of these areas is identified in the pipeline inventory (i.e., Table 2.15-4, reference to site on p. 25 of the pipeline map atlas (Dames & Moore, 1998); coincides with Mass-Wasting Map Unit 14a on the inventory performed for watershed analysis (Plum Creek Timber Co., 1997a)). Regulatory prescriptions currently are being drafted for these three areas.

Regulatory prescriptions, therefore, are available for the Tolt and Griffin-Tokul WAUs.

The Tolt Watershed Analysis (Weyerhaeuser Co. 1993) currently is being reviewed as part of the 5-year regulatory-review process (WAC 222-22-090(4)) and draft prescriptions are available. The WDNR uses draft prescriptions from ongoing watershed analyses to condition forest-practices applications where such prescriptions would have greater potential than standard rules for minimizing material delivery from mass-wasting sites to areas with vulnerable public resources (WAC 222-22-090(2)). (See written testimony of Nancy Sturhan for more discussion of regulatory prescriptions.) Hence, the WDNR region staff would apply draft prescriptions concerning mass-wasting units in the Tolt, Keechelus Lake, and Mosquito WAUs to any forest-practices applications proposed in those sites.

Q. What is stated in the regulatory prescriptions identified in the preceding question? What is the pipeline proposal for these sites?

A. If the WDNR, Forest Practices, were to approve forest-practices aspects of the pipeline application, the pipeline proposal would have to comply with draft and/or final prescriptions for mass-wasting sites identified in the preceding question:

(1) Tolt WAU -

It appears that two mass-wasting sites identified in the pipeline landslide inventory (those indicated in OPL, 1998, Table 2.15-4 as corresponding to map atlas page 11 (Dames & Moore, 1998)) coincide with Mass-Wasting Map Units 20 and 21 delineated in the Tolt Watershed Analysis (Weyerhaeuser, 1993, Appendix A). However, no specific locations are given in the application to verify that they are the same. Mass-Wasting Map Units 20 and 21 Weyerhaeuser Co., 1993) include two ancient, deep-seated landslides on the north and south valley walls of the Tolt River at Stream Crossings 26 and 27 (Dames & Moore, 1998). The larger, deep-seated features contain localized areas of instability that have failed as shallow, rapid landslides in the recent past. The regulatory watershed analysis identified that road construction and undermining of the toes by the river have exacerbated failure activity, due to increased concentration of surface and subsurface water, decrease in root strength, and loss of lateral support when the toe of the slope is eroded.

Prescriptions call for detailed slope-stability analyses and geotechnical site evaluations as part of any Forest Practices Application (FPA) submitted for these sites (see copies of prescriptions appended to the written testimony of Nancy Sturhan (WDNR)). Hence, the WDNR would require that these analyses and reports be completed prior to approval of any forest-practices application (RCW 76.09.060(e),(g),(I)). The WDNR would also require that a site-specific design plan and map, including descriptions of the proposed methods, materials, and equipment, be included in the application. The pipeline application (OPL, 1998, Table 2.15-5) also indicates a need for additional geotechnical work, but these evaluations would be done after application approval. The WDNR would find this unacceptable because of the likelihood for the pipeline proposal (e.g., alignment, construction methods and timing, mitigation measures) at this site to be modified by the outcome of a full investigation of the potential for pipeline construction to reactivate failure activity, the potential delivery of landslide sediment to the river, and the consequences of such delivery to vulnerable resources downstream.

(2) Griffin-Tokul WAU:

The pipeline landslide inventory indicates two failures in the vicinity of the Griffin Creek crossing (OPL, 1998, Table 2.15-4; see p. 12 of the pipeline map atlas (Dames & Moore, 1998)). These sites coincide with Mass-Wasting Map Units 7 and 13 (Weyerhaeuser Co., 1995)).

Regulatory prescriptions for the Griffin-Tokul WAU address timber harvest and road building in Mass-Wasting Map Unit 7 (see Weyerhaeuser Co., 1995, Prescriptions section, p.10; see copies of prescriptions appended to the written testimony of Nancy Sturhan (WDNR)). This unit includes the north side of Griffin Creek, which is flanked by a re-activated, ancient deep-seated landslide. This failure, and several shallow, rapid failures occurring on its toe (i.e., the end next to the creek), were re-initiated by road drainage from a spur road and removal of lateral slope support during road construction (Weyerhaeuser Co., 1995). In addition, all or portions of the deep-seated failure have the potential for accelerated movement if surface water is concentrated in the body of the landslide, vegetation is removed from the failure surface, and/or the landslide toe continues to be undermined by the creek (Weyerhaeuser Co., 1995, Appendix A, Mass Wasting Module Report).

The watershed-analysis team rated this deep-seated failure as having a high potential for re-activation and material delivery to Griffin Creek (Weyerhaeuser Co., 1995, Prescriptions section, p. 10). In contrast, the mass-wasting inventory performed for the proposed pipeline route (OPL, 1998; see Table 2.15-5) rated this site as having a low hazard potential for deep-seated failure and moderate potential for shallow failures on its surface. The higher rating given by the watershed-analysis team likely is due to the fact that potential delivery of landslide materials to waters of the state was incorporated in the rating scheme. In the watershed-analysis process, hazard ratings are based on probability of mass wasting and potential for delivery of landslide materials to waters of the state (see WFPB, 1997, p. A-29, Table A-2). Based on my reading of the application and DEIS, it does not appear that deliverability and material damage to public resources was part of the equation in assigning hazard ratings to mass-wasting sites.

The objective of the regulatory prescription for Mass-Wasting Map Unit (MWMU) 7 in the Griffin-Tokul WAU is to prevent sediment delivery to Griffin Creek from landslide re-activation associated with timber harvest and roads. The public-resource objective is stated in the prescriptions: "Landslides from MWMU 7 can deliver fine sediment to the channel resulting in sediment delivery to downstream reaches, potentially reducing [salmon] egg survival" (Weyerhaeuser Co., 1995, Prescriptions section, p. 10).

The prescriptions for MWMU 7 (see Weyerhaeuser Co., 1995, Prescriptions section, p.11) include:

(1) No road construction or reconstruction.

(2) Clearcut harvest shall proceed only when low delivery potential, or low hazard potential is determined by a [WDNR-] certified (level 2) mass wasting analyst ... Partial cut can proceed with verified moderate delivery and hazard.

(3) Harvest shall avoid exposing mineral soil.

The pipeline proposal at this site is to run the pipeline down the body of the deep-seated failure (i.e., parallel to the slope fall line) and cross underneath Griffin Creek (see Dames & Moore, 1998, p. 12). This would require extending the existing right-of-way maintained by Bonneville Power Authority; the right-of-way ends on either side of Griffin Creek at the point where the hillslope dips steeply downward to the creek. The mitigation measure proposed for this site is to increase burial depth of the pipeline from an average four feet to an unspecified amount. No other measures are considered.

In my opinion, this site proposal is analogous to constructing a 30-foot wide road (i.e., average measurement of cleared and maintained right-of-way; OPL, 1998, p. 2.10-3, para. 1) down the length of the landslide. [See written testimony by Ronn Schuttie, WDNR, for additional discussion about road and right-of-way issues, including right-of-way permanence] This is because the right-of-way would be excavated to bury the trench, and it would be maintained as a cleared, driveable access for operation and maintenance

(OPL, 1998, 2.3-4 to 2.3-5). Inserting a pipe in the ground and maintaining a driveable access would alter the soil properties and hydrology of the site. Soils in the right-of-way subgrade likely would lose strength, due to permanent removal of large tree roots, and to concentrated flows of surface water on the right-of-way surface and within the trench fill (e.g., see WFPB, 1997, p. B-5). Both factors (i.e., loss of root strength and increased surface flow) have been identified in this site as potential triggering mechanisms for shallow and deep-seated movement (Weyerhaeuser Co., 1995, Prescriptions section, pp. 10-11).

(3) Keechelus Lake - Mosquito Creek WAUs -

The pipeline landslide inventory identifies only one of three unstable slope areas mapped in the watershed analysis (i.e., Table 2.15-4, reference to site on p. 25 of the pipeline map atlas (Dames & Moore, 1998); coincides with Mass-Wasting Map Unit 14a on the inventory performed for watershed analysis (Plum Creek Timber Co., 1997a)). In this area, snow avalanches, deep-seated bedrock failures and shallow, rapid landslides have been identified as having a high potential for delivering sediment to the John Wayne Trail (i.e., a public works) on which the proposed pipeline would be constructed (Plum Creek Timber Co., 1997a, Causal Mechanism Reports (CMR) section, p. 19). The watershed analysis report states:

> "The vulnerability of the John Wayne Trail, BNSFRR [Burlington-Northern Santa-Fe Railroad], and I-90 is high where these linear public works intersect

MWMU [Mass-Wasting Map Unit] 14a. Sediment delivered from slope failures from mass wasting map unit 14a could damage these public works, thereby potentially disrupting service or use, incurring maintenance or repair cost, and threatening public safety." (Plum Creek Timber Co., 1997a, CMR section, p. 19)

The pipeline proposal at this site is to bury the pipeline under the trail, with no additional mitigation measures. The rationale given in the application is that "avalanches are not anticipated to have the potential to adversely impact pipeline operations due to the proposed burying of the pipeline" (OPL, 1998, p. 2.15-25). This statement is not supported with any analysis or further discussion. It is contrary to the findings of the watershed analysis (see previous paragraph).

Additionally, the proposed pipeline route traverses two mass-wasting sites that are identified in the regulatory watershed analysis but not in the pipeline landslide inventory. These areas are identified in Plum Creek Timber Co. (1997a, CMR section pp. 1-6) as Mass-Wasting Map Units 5a and 6. These mass-wasting map units comprise a number of shallow-rapid landslide and debris-flow-related failure sites that are found on locally steep sections of hilllslope along the western side of Keechelus Lake. These failure sites are upslope of the proposed pipeline route (see Plum Creek Timber Co., 1997a, Map A2a; Dames & Moore, 1998, pp. 26-28). The same threats to the pipeline corridor and the John Wayne Trail exist in these sites as explained above for Mass-Wasting Map Unit 14a.

Hence, there appear to be numerous segments of the proposed pipeline, in the vicinity of Keechelus Lake, that could be damaged by shallow, rapid landslides and debris flows. If the WDNR were approving the pipeline application, the department would require that all potential failure sites on private and state lands be analyzed in the field and their effects on the John Wayne Trail be described in the application. The department also would require, prior to application approval, site-specific construction designs that would indicate how the buried pipeline could withstand mass-wasting events and what mitigation measures would be used to minimize this potential. The application also would have to comply with regulatory prescriptions written for the Keechelus Lake - Mosquito Creek WAUs, as soon as they become available. However, the WDNR likely would condition the pipeline application based on the findings of potential damage to the John Wayne Trail, as described above.

Q. What would the pipeline company have to do to comply with regulatory prescriptions identified in the preceding question?

A. If the WDNR were the primary permitting authority with respect to the pipeline application, a number of issues would need to be addressed in the SEPA document *prior* to approval of forest practices related to pipeline construction. [SEPA checklists are required for Class IV-Special applications (i.e., those that propose operations on unstable slopes, as per WAC 222-16-050)]. The following would need to be evaluated in light of their potential to affect, or be affected by, slope stability:

For the Tolt and Griffin-Tokul WAUs -

(1) road construction and maintenance of a permanently cleared right of way;

(2) removal of forest vegetation as part of right-of-way development;

(3) disrupting identified deep-seated failure surfaces and partially removing overburden along the axis of these features while building the pipeline trench;

(4) potential removal of lateral support at the base of identified deep-seated landslides, associated with pipe installation under the channel and under the failure surface, as well as excavating a 60-foot by 100-foot staging area for stream-crossing construction; and,

(5) potential for the pipeline trench to concentrate and funnel water into the bodies of the identified deep-seated failures;

For the Keechelus Lake - Mosquito Creek WAUs -

(6) potential for landslides and debris flows, emanating from upslope source areas, to erode sections of the John Wayne Trail and damage or sever the buried pipeline; and,

(7) potential for disturbing the integrity of the John Wayne Trail, resulting in material delivery to nearby waters (e.g., failing to reinstall adequate cross drains and concentrating runoff onto unstable fill).

With respect to the Tolt and Griffin-Tokul WAUs, factors 1 through 5 (i.e., road construction, vegetation removal, surface disturbance, loss of lateral support, and water concentration) have been identified in the watershed analyses (Weyerhaeuser Co., 1993, 1995) as potential triggering mechanisms for re-activating mass wasting and delivering sediment to the creek. None of these factors, with the exception of (4), has been addressed in the pipeline application or Draft Environmental Impact Statement (DEIS). Factor (4) is addressed in one sentence, indicating that the potential for slope undermining "could be reduced by performing detailed reconnaissance just prior to construction ... and by maintaining geotechnically trained personnel onsite during construction in those areas" (DEIS, 1998, p. 3.23). As stated previously, WDNR would require a geotechnical analysis and site-specific construction plan up front prior to application approval, to evaluate the site and its potential for material delivery to waters with vulnerable public resources, as per RCW 76.09.060(1).

Notwithstanding, it is likely that the WDNR, Forest Practices, would not permit the forest-practices-related proposal, in its current form, for the Griffin Creek site (i.e., deep-seated failure identified on p. 12 of the map atlas (Dames & Moore, 1998) and in Table 2.15-4 (OPL, 1998)) because:

(1) construction or reconstruction of the right-of-way road violates regulatory prescription (1) (i.e., the prescription stipulates no road construction or reconstruction at this site; see previous comment in this testimony); and,

(2) vegetation and overburden removal, in addition to jeopardizing stability of the

landslide toe during pipe installation, has a high potential for re-initiating slide movement, delivering sediment to a Type 1 Water, and potentially adversely impacting downstream fish habitat (see Weyerhaeuser Co., 1995, Prescriptions section, pp. 10 and 11).

Therefore, the WDNR likely would require that the pipeline be realigned at the Griffin Creek site, to an area outside Mass-Wasting Map Unit 7 as identified in the watershed analysis (Weyerhaeuser Co., 1995), or alternative construction plans be designated (e.g., bridge or overpass crossing) that would minimize disturbance of the deep-seated failure.

Likewise, the identified mass-wasting site on the south side of Griffin Creek would require a geotechnical analysis of right-of-way road construction prior to application approval (i.e., Mass-Wasting Map Unit 13 (Weyerhaeuser Co., 1995); coincides with mass-wasting site on map atlas p. 12 (Dames & Moore, 1998; see OPL, 1998, Table 2.15-5)). The watershed-analysis prescription for this site also stipulates no road construction or reconstruction (Weyerhaeuser Co., 1995; Prescriptions section, p. 19).

Q. Is the potential addressed in the pipeline application or DEIS for pipeline construction to initiate or re-initiate landslides?

A. Yes, the potential is addressed but in a cursory and incomplete manner. I could find only limited references to pipeline construction or maintenance as a possible trigger of landslide activity. A list of potential impacts, with no further discussion, is given on page 3-28, DEIS (1998), and there is no discussion in the application (OPL, 1998). This list includes funneling water along pipeline trenches and into mass-wasting sites, failure of trench backfills, and erosion beneath the pipeline.

The DEIS, however, does not provide an analysis of these impacts with respect to identified mass-wasting sites. The pipeline application addresses the potential impacts of mass wasting on the integrity of the pipeline (e.g., see OPL, 1998; p. 2.15-23), but not vice versa.

In my opinion, the pipeline application should address the potential for construction-related landslide initiation. Insufficient information is provided in the application or DEIS to evaluate the potential risks of building a pipeline through unstable ground. Without site-specific construction designs and trench locations, as well as geotechnical analyses of landslide properties and behavior, it is difficult to assess the feasibility and success of locating a pipeline across landslide areas with the potential for continued or renewed failure. In addition, it is difficult to weigh the relative risks of construction-triggered to sensitive public resources without having some idea of site-specific landslide characteristics and proposed construction designs. Hence, I think that a risk analysis should be performed prior to application approval, rather than afterwards as has been proposed in the application (OPL, 1998; p. 2.15-26) and DEIS (p. 3-28). The outcome of the risk analysis, particularly for highly unstable slopes, likely would influence decisions regarding proposed pipeline alignment, construction specifications, and mitigation measures. The WDNR, for example, would require such information up-front, because of its potential for altering the final, approved work plan. See answers to following two questions for more discussion on these issues.

Q. In your opinion, do the DEIS and application provide a complete assessment of risk factors related to unstable slopes?

In my opinion, the application and DEIS do not present an adequate evaluation of potential adverse impacts to public resources of material delivery from existing and potential mass-wasting sites that might be disturbed as a result of pipeline construction, operation, or maintenance.

The pipeline application and DEIS primarily address protective measures that would be implemented to reduce the risk of pipeline damage (e.g., OPL, 1998, p. 2.15-23, para. 1), rather than ones designed to minimize resource impacts. For example, a list of mass-wasting impacts appears in the DEIS (1998; p. 3-22), with no further discussion or risk analysis. This list includes:

(1) undermining the toe of a steep slope or landslide, which could trigger mass wasting and deliver fine-grained soil to adjacent streams and wetlands; and,

(2) stockpiling sediment or trench spoils which, if placed on steep slopes or in landslide areas, could fail with potential material delivery to streams and wetlands.

The pipeline application (OPL, 1998) does address some potential impacts to fishery resources and water quality as a consequence of pipeline installation (e.g., see OPL, 1998, p. 3.4-73 through 3.4-113). However, I could find no discussion of the link between material delivery from mass-wasting sites and potential degradation of these public resources. For example, the application (OPL, 1998, p. 3.4-73) states:

> "In general, the primary potential impacts to fishery resources from pipeline installation and associated construction are from water quality degradation and physical alteration of in-stream and stream-adjacent habitat."

The application and DEIS do not appear to address mass wasting, potentially initiated by pipeline construction, as a contributor of downstream habitat and water-quality impacts.

Q. In your opinion, what additional steps would need to be taken to assure compliance with forest-practices standards (outside watershed analysis) regarding unstable slopes?

A. If the forest-practices-related elements of this project were regulated by the WDNR, Forest Practices, the following general steps would be required to complete the current application and assure that forest practices meet minimum standards as specified by Chapters 222-24 WAC (road construction) and 222-30 WAC (timber harvest) as they pertain to unstable slopes. This would apply to all 51 landslides identified in Table 2.15-5 (OPL, 1998, p. 2.15-24 to 2.15-25) and others not identified in the landslide inventory (e.g., those sites mentioned previously in this testimony, and potentially others that might be discovered if a complete landslide inventory of the proposed route were completed).

This discussion does not address specifics of the application approval or SEPA process.

The following steps have been developed by WDNR to carry out its mandated responsibility to assure that applications meet forest-practices minimum standards (RCW 76.09.040; WAC 222-12-010). These are the procedures and levels of information considered necessary by the department to complete a fair and accurate assessment of the potential impacts of proposed activities on public resources (RCW 76.09.060(1); WAC 222-20-010(2)).

(1) Proposals for right-of-way road construction and timber harvest along the pipeline corridor, as outlined in the current pipeline application (OPL, 1998), would be categorized as Class IV - Special because of identified mass-wasting sites with direct delivery to waters of the state (e.g., as in the case of the deep-seated landslide at Griffin Creek, as previously described in this testimony; see WAC 222-16-050).

(2) As a Class IV - Special application, an environmental checklist, per SEPA (chapter 43.21 RCW), would be required. As part of the SEPA process, a field geotechnical assessment of all mass-wasting sites and potential for material delivery to public resources also would be required (RCW 76.09.060(1), WAC 222-10-010(5), and WAC 222-20-010(2)). The pipeline application and DEIS do not provide any site-specific geotechnical analyses of landslide properties and potential for material delivery to public resources.

(3) As per RCW 76.09.0609(1), the following would be required. For each proposed

pipeline segment that crosses private and state forest-lands on identified unstable ground, the WDNR would require a site development plan, including information on proposed construction and harvest activities, and their likely impact on slope stability. For right-of-way road construction, this would include a map and description of such factors as proposed road location, road and right-of-way widths, construction methods and equipment, drainage-structure type and spacing, surfacing, permanence, and maintenance (see written testimony supplied by Ronn Schuttie, WDNR Forest Practices Division), and the potential for each or all these factors to promote mass wasting. For harvest in the right of way, a plan would include descriptions of harvest methods and equipment, and their potential impact on mass wasting. In addition, the WDNR would require that the boundaries of each construction site, as well as the perimeter of unstable areas, be flagged on the ground so that WDNR staff are able to review proposed operations in the field.

(4) The WDNR, Forest Practices, would approve geotechnical reports based on internal field reviews and analyses by staff scientists.

(5) WDNR staff (e.g., forester, geomorphologist or hydrologist) would make field determinations regarding the relationships between the proposed forest-practices activities (road construction and harvest), mass-wasting processes and potential for construction or maintenance practices to cause material delivery to waters of the state, and likelihood that public resources would be adversely impacted (RCW

76.09.150). Such field determinations might (and usually do) include T/F/W cooperators (i.e., from government agencies, tribal governments, environmental groups, and timber companies) and landowners with vested interests in, or scientific/management knowledge of, the sites.

(6) The WDNR would approve or disapprove the application based on potential likelihood of material delivery from mass-wasting sites to public resources, resulting from pipeline construction and maintenance (WAC 222-10-101(4)). The application might be approved contingent on special conditions that modify management activities, with the aim of minimizing potential material delivery and adverse impacts to public resources.

In its current form, the pipeline application does not provide enough site-specific information related to mass-wasting conditions and construction plans, to permit such a regulatory review and approval. The pipeline application states that such documents would not be developed until *after* application approval, which would be unacceptable to the WDNR, Forest Practices.

Therefore, all specific site-construction plans, field analyses of potential road-construction and timber-harvest impacts to unstable slopes, mitigation plans, and accompanying geotechnical reports would be required by the WDNR *prior* to application approval.

WDNR recommends that EFSEC require a process similar to that outlined above, if the full impacts of pipeline development on unstable ground and public resources are to be assessed accurately prior to application approval. It would be difficult to assure the effectiveness of the generic operational and mitigation plans outlined in the pipeline proposal (OPL, 1998, p. 2.15-26 through 2.15-30), without having a complete landslide inventory, site-specific geotechnical reports, and site-specific construction plans and mitigation measures based on the geotechnical analyses. Furthermore, the applicant does not provide EFSEC with any indication that the appropriate geotechnical analyses would be performed for each mass-wasting site following application approval.

Q. Do the pipeline application and DEIS address impacts associated with mass wasting?

A. Yes, but I believe that the discussion is cursory and incomplete.

The pipeline application indicates that mass wasting has the potential to adversely impact construction and operation of the pipeline (e.g., by "movement of soil into excavations during installation, the movement of soil onto the pipeline after installation, and/or the loss of foundation support after installation" (OPL, 1998; p. 2.15-23).

I found only minimal references in the DEIS (1998), regarding the potential impacts of pipeline construction on the initiation or re-initiation of mass wasting. As stated previously in this testimony, some potential generic cause-effect relationships are listed, but there is no further discussion or risk assessment.

I also could find only minimal reference in the DEIS regarding the potential adverse impacts to public resources associated with material delivery from mass-wasting events triggered by pipeline construction, operation, and maintenance. This discussion comprises a potential list of cause-effect relationships (DEIS, 1998, pp. 3-22 to 3.23) with no additional explanation or risk assessment of at least the most critical mass-wasting sites along the proposed pipeline route (e.g., those listed as having high hazard potential; DEIS, Table 3.2-4).

Hence, I believe that the analysis of project impacts is incomplete with respect to mass-wasting processes. To be complete, the pipeline application would need to provide an analysis of the following issues, for those mass-wasting sites with a moderate or high potential for failure (see RCW 76.09.060(1) and WAC 222-16-050(1)(d)(e)):

(1) slope-stability parameters such as material properties, hydrologic conditions, structural features, and evidence of instability (e.g., a geotechnical analysis);

(2) potential impacts of pipeline construction on mass-wasting initiation;

(3) probability of landslide-debris delivery to waters of the state; and,

(4) potential adverse impacts of such delivery to public resources.

Q. Have any mitigation measures been identified that address expected impacts related to mass wasting? If yes, identify these mitigation measures.

A. Yes, some generic mitigation measures have been identified. However, I could not evaluate their appropriateness or potential for success, due to the fact that the application and DEIS did not provide enough information (see following paragraphs for detail).

The pipeline application states that (OPL, 1998, p. 2.15-23, para. 1):

> "... the proposed route and related facilities generally avoid areas with known potential for mass wasting where possible. However, portions of the pipeline corridor cross slopes which have been mapped as having moderate to high potential for mass wasting and could impact the pipeline."

Specific mitigation measures have been summarized (see their Table 2.15-5) for mass-wasting sites deemed by the company to be unavoidable.

Mitigation measures, where proposed, are preliminary and hinge on more detailed geotechnical analyses *following* approval of the application by EFSEC. Hence, I do not believe that it is possible to evaluate the current pipeline documents with respect to the nature and severity of potential impacts, or the feasibility and success of proposed mitigation measures. Additional information is required.

In my opinion, such an evaluation of expected impacts and mitigation measures would require that the following be completed:

(1) site-specific geotechnical assessments;

(2) field analyses of slope stability (qualitative or quantitative, to the extent allowed by current methods);

(3) detailed construction plans; and,

(4) a more detailed analysis of mitigation measures at each site, including general design, expected outcomes, and potential impacts of installing mitigation

measures on slope stability and material delivery to public resources.

None of these study components have been included in the pipeline application and DEIS.

If the WDNR, Forest Practices, were the primary permitting authority for pipeline activities involving forest practices, these four elements would be required *prior to approval of the application* (as per WDNR regulatory authority under RCW 76.09.060). Given that each site has its own set of physical characteristics and complications, it would be difficult to evaluate the potential for landslides, material delivery, and public-resource impacts to occur as a result of pipeline construction without knowing the landslide properties and construction plans at each site. In addition, it is difficult to analyze the potential success of mitigation measures without knowing what needs to be mitigated at each site.

Q. *Have proposed mitigation methods been analyzed in terms of their potential for stabilizing and destabilizing unstable slopes?*

A No, risk assessments of mitigation measures have not been addressed.

The pipeline application and DEIS identify eight potential mitigation methods, one or several of which might be selected for a particular pipeline traverse of unstable slopes. Design of mitigation measures is contingent on approval of the pipeline application by EFSEC and subsequent site-specific geotechnical analyses.

These eight mitigation measures have not been analyzed in terms of their likely influence on stabilizing or destabilizing slopes. Furthermore, the application and DEIS do not reference any studies or factual information indicating that such measures would be appropriate, feasible, and successful in the types of mass-wasting features found along the proposed pipeline route.

In addition, some of the proposed mitigation measures appear to me to be problematic technically, at least as they are currently posed in the pipeline application (OPL, 1998, pp. 2.15-29 to 2.15-30; DEIS, 1998, pp. C-9 to C-10). There is not enough information in the document to evaluate how the following measures would be carried out on the ground, or whether they would contribute to pipeline and hillslope stability:

(1) Proposed method: Avoidance.

> This measure involves moving the proposed pipeline corridor away from mass-wasting sites with a moderate to high potential for failure, “where possible” (OPL, 1998, p. 2.15-29). The criteria used to define “where possible” are not explained. In fact, it appears that the pipeline route was realigned in only 9 of 34 identified sites with a moderate to high hazard potential. Furthermore, there is no site-specific information in the application or DEIS to evaluate the potential for other mitigation measures, prescribed for the remaining 25 sites (OPL, 1998, pp. 2.15-28 to 2.15-29), to prevent or avoid initiating mass-wasting events.

(2) Proposed method: Reorientation of the pipeline against slope.

There is no rationale presented in the application and DEIS as to why orienting the pipeline at right angles to the slope fall direction would decrease mass-wasting-induced pipe damage. In some identified sites (e.g., the deep-seated failure at Griffin Creek, described earlier in this testimony), excavation of the failure surface to install the pipe likely could increase the already-high potential for initiating mass movement, regardless of pipe orientation.

If, for example, movement occurs in a deep-seated landslide whose failure plane (i.e., the base of the landslide) is several tens of feet below the surface, it might not matter how a shallowly buried pipe is oriented. The pipe is susceptible to being rafted downslope, along with trees, power lines, and other structures anchored in the moving mass.

(3) Proposed method: Drainage.

Without site-specific geotechnical analyses, it is difficult to evaluate whether the mass-wasting sites for which drainage relief has been prescribed (OPL, 1998, pp. 2.15-28 to 2.15-29) would respond positively to such treatment. Drainage manipulation also has the potential to enhance slope failure if not done correctly. The application does not address the methods that would be used to identify appropriate drainage alterations, any analyses that would be performed to evaluate the risks of using this mitigation measure over some other, or the methods by which such measures would be installed and monitored for long-term effectiveness.

(4) Proposed method: Increasing burial depths of the pipeline.

This method presumes that pipeline excavation, particularly to depths greater than a few feet in the body of active landslides, would not contribute to physical factors promoting slope failure (e.g., alteration of surface and subsurface drainage, changes in soil properties associated with digging a trench and building a 30-foot-wide right of way on either side). The validity of this assumption has not been addressed adequately, if at all, in the application and DEIS. It is not supported with any geotechnical analyses or factual information.

Given the documented instability of some mass-wasting sites (e.g., the deep-seated failures at Griffin Creek and south of the Tolt River (see Weyerhaeuser Co., 1993, 1995, in preparation; and OPL, 1998, Table 2.15-5, failure located south of stream-crossing 27)), the potential exists that digging deeper into the unstable slope could actually cause a landslide. Hence, a risk analysis of the proposed mitigation measure should be performed for every mass-wasting site with a moderate or high potential for slope failure.

Furthermore, the pipeline application and DEIS do not list procedures for demonstrating to EFSEC that the appropriate evaluations of site-specific geotechnical information (i.e., necessary to select the correct mitigation measure) and mitigation methods would be completed following approval of the application. Hence, I would recommend that the requisite geotechnical analyses and site construction designs be included in the application, so that EFSEC can fully evaluate the impact to public resources of the pipeline project.

If the WDNR were responsible for permitting the forest-practices activities in the pipeline proposal (e.g., road construction and timber harvest on unstable slopes), a specific mitigation plan would be required prior to application approval. Such a plan would need to include a detailed description of the mitigation measure (e.g., purpose, methods, exact location and physical dimensions, type of construction equipment, type and function of hardware left on-site), and a benefit-risk analysis of its likely influence on slope stability. Without such information, it would be difficult to evaluate the real success of mitigation measures in minimizing or preventing mass wasting associated with pipeline and right-of-way construction, because the specific site conditions govern the feasibility and success of such measures.

In addition, the WDNR would require rationale and discussion regarding why some unstable slopes were considered unavoidable for pipeline development on this proposed route (OPL, 1998, p. 2.15-23). With the exception of 9 (out of 34) mass-wasting sites, no local alternatives (e.g., pipe realignments) appear to have been evaluated to route the proposed pipeline around individual mass-wasting sites identified in Table 2.15-5 (OPL, 1998) as having a moderate to high hazard potential.

Q. Are there existing or potential mass-wasting sites that are not referenced in the pipeline *application or DEIS? Do these sites have a potential for material delivery to areas in which public resources would be impacted adversely?*

A. Yes, several mass-wasting sites with high potential for failure and material delivery have been omitted from the landslide inventory provided in the application and DEIS.

As mentioned previously in this testimony, there are several mass-wasting sites, identified in state regulatory watershed analyses, that are not mentioned in the pipeline documents and that have potentials for material delivery to public resources (see previous comments in this testimony regarding identified mass-wasting sites in the Keechelus Lake - Mosquito Creek WAUs). In addition, WDNR South Puget Sound Region staff have identified a number of geographically extensive areas in which existing and potential mass wasting from abandoned, orphaned, and inactive roads upslope of the proposed pipeline corridor could compromise the pipeline and public resources in streams adjacent to the pipeline (see written testimony by David Weiss, WDNR, South Puget Sound Region).

These field analyses indicate that abandoned, orphaned, and inactive roads upslope of the South Fork Snoqualmie River have produced, and continue to produce, debris avalanches that turn into debris flows once they enter stream channels with flowing water (see definition of terms in the answer to the second question in this testimony). The abandoned, orphaned, and inactive roads are located upslope of the proposed pipeline corridor in sections 31, 32, and 33 (T23N, R9E), sections 3, 4, and 12 (T22N, R9E), sections 16, 17, 18, 21, 22 (T22N, R10E), and section 17 (T22N, R11E) (see pp. 18-24, map atlas prepared by Dames & Moore, 1998). These erosive debris flows scour stream channels that are tributaries (i.e., side channels) to the South Fork Snoqualmie River, often to bedrock. They are capable of depositing substantial amounts of sediment and organic debris in the river. Debris-flow activity has caused many tributary channels to cut down (i.e., incise) through their streambeds and other slope features (e.g., roads located downslope). Hence, the proposed pipeline corridor is at risk from being damaged or severed by debris flows, wherever tributary channels intersect unstable portions of abandoned, orphaned, and inactive roads. Hazard sites would include any Type 4 or 5 water[2] that intersects the abandoned, orphaned, or inactive roads and pipeline route on pages 18-24 of the map atlas (Dames & Moore, 1998). Because these debris flows typically scour channels to their bedrock basement, segments of buried pipeline likely would be susceptible to damage, including pipe rupture.

Given the abundance of existing debris-flow paths and potential for numerous additional failures of road prisms in abandoned, orphaned, and inactive roads, the probability of multiple breaks in or damage to the pipeline is increased. Sediment from landslides and debris flows would have considerable adverse impacts on water quality and vulnerable fish habitat in the South Fork Snoqualmie River (see written testimony of Gary Sprague, WDFW, for further discussion of biological impacts).

Q. Based on the preceding testimony, what are your summary recommendations?

A. If WDNR were the permitting authority with respect to the pipeline application, a number of additional analyses and pieces of information would be required prior to approving the application. Hence, WDNR recommends that EFSEC require the following (see detailed discussions of each item in the preceding testimony):

(1) The applicant complies with all WACs regarding road construction and timber removal on unstable slopes.

(2) The applicant complies with all regulatory prescriptions from watershed analyses that pertain to unstable slopes crossed by the proposed pipeline corridor. The application does not mention existing regulatory prescriptions, which could impact pipeline alignment and construction at several sites.

(3) A complete, field-verified mass-wasting inventory be included in the application. The current inventory is incomplete, and several sites with high potential hazard for impacting the pipeline and public resources have not been addressed.

(4) For each mass-wasting site, the application needs to provide a detailed geotechnical analysis of mass-wasting location, behavior, material properties, drainage, and potential for natural or management-related failure. In addition to a detailed site construction plan, such information is needed up front to evaluate the potential for pipeline construction to impact unstable slopes and deliver materials to vulnerable public resources.

(5) For sites rated with a high potential for mass wasting (i.e., using the rating scheme in the application), alternative methods be analyzed for carrying the pipeline across unstable slopes (e.g., overpasses). The application contains no discussion of alternatives to pipeline burial.

(6) For each mass-wasting site, the application needs to provide a detailed site construction plan, including layout, methods, materials, equipment, pipeline trench position and fill/drainage, timber harvest, road location and type, road

drainage and surfacing, revegetation plans, and mitigation measures. These components have the potential for exacerbating soil movement in existing or potential mass-wasting sites.

(7) Geotechnical analyses and construction plans be reviewed in the field by the regulating authority or authorities, prior to application approval, to verify that minimal potential impact to public resources has been achieved. The WDNR would require that the site layout (e.g., boundaries, road or right-of-way locations, perimeters of unstable-slope areas) be flagged on the ground to aid the regulatory reviewers in evaluating potential risks to unstable slopes and affected public resources. The review team should include person(s) trained in evaluating road-construction and timber-harvest methods, geomorphologist(s) or hydrologist(s) trained in evaluating slope stability, and person(s) trained in assessing the impacts of forest practices and mass wasting on public resources. WDNR staff are experienced with these issues on state and private forest lands.

(8) Site-specific mitigation measures be designed for each site, and the potential impacts to slope stability and affected public resources of these measured be analyzed. The application contains no site-specific mitigation measures, nor an assessment of potential impacts of mitigation measures. The WDNR would require such information to evaluate the relative risks of installing these measures.

CHANNEL CROSSINGS

Q. Do the Washington Forest Practices Act and associated regulations address stream crossings and road building across channels? If so, how are they addressed?

A. Yes, stream crossings are addressed in the forest-practices regulations but mostly in association with road construction (see discussion of WACs in the following paragraphs). Other state agencies assume lead responsibilities for regulating operations in channels (i.e., areas identified by the transport of sediment and water confined between definable beds and banks). Hence, there are no WACs administered by the WDNR that pertain directly to excavating and operating within stream channels.

The Washington Department of Fish and Wildlife (WDFW) assumes the primary responsibility for issuing and enforcing hydraulic project approvals (HPAs) for work in or above the ordinary high-water mark of Types 1, 2, and 3 waters (and, in some instances, Types 4 and 5 waters) (RCW 75.20.100). WDNR, however, enforces road and timber-harvest rules (222-24 and 222-30 WAC, respectively) when road-construction or timber-harvest violations occur within the channel and its floodplain.

The Washington Department of Ecology (WDOE) administers the Water Pollution Control Act (RCW 90.48), which addresses water-quality issues such as turbidity (i.e., sediment delivery and concentration from, for example, road beds). The WDNR assumes the enforcement lead when forest-practices activities (e.g., road construction in stream crossings) damage public resources.

Chapter 222-24 WAC ("Road construction and maintenance") mentions stream crossings with respect to road locations:

(1) "Minimize roads along or within narrow canyons, riparian management zones, wetlands and wetland management zones.

(a) Except where crossings are necessary, roads shall not be located within natural drainage channels and riparian management zones when there would be substantial loss or damage to wildlife habitat unless the department has determined that alternatives will cause greater damage to public resources." (WAC 222-24-020(2)(a))

(2) "Minimize the number of stream crossings." (WAC 222-24-020(3))

(3) "Whenever practical, cross streams at right angles to the main channel." (WAC 222-24-020(4))

(4) "Properly prepared and maintained fords may be used during periods of low water providing a hydraulic permit is acquired." (WAC 222-24-040(5))

The application states that (3) is addressed as a mitigation measure (OPL, 1998, p. 1.4-29). It does not appear that (1) and (2) are addressed explicitly in the application or DEIS. Given that an HPA might or might not be required by EFSEC, the applicability of (4) is unclear. It also is not clear in the application how maintenance vehicles would ford streams along the pipeline route, nor has there been an analysis of the potential disturbances of such use on the channel and public resources therein.

Road building through stream channels also is addressed in the regulatory watershed-analysis process (WFPB, 1997, Appendix B). Regulatory prescriptions limiting crossing construction, use, and maintenance are authorized if a material link is made between such activities (e.g., sediment delivery, channel scour or deposition, changes in channel or floodplain form and function) and adverse impact to fish habitat, water quality, and capitol improvements of the state (WAC 222-22-010(4)). See written testimony of Nancy Sturhan for additional discussion of the regulatory watershed-analysis process.

Timber harvest associated with right-of-way construction in the vicinity of riparian management zones and channel crossings is discussed in written testimony of Todd Bohle (WDNR).

Q. How do the forest-practices regulations define and address channel migration zones?

A. Channel migration zones are not addressed explicitly in the current forest-practices regulations (WFPB, 1997). However, they are defined and addressed in the regulatory watershed-analysis process. The new forest-practices rules resulting from T/F/W Forestry Module negotiations are expected to explicitly describe permitted management activities in channel migration zones and methods for delineating those zones on the ground.

According to the watershed-analysis manual (WFPB, 1997, p. D-15):

> "The channel migration zone, for the purpose of this [riparian-function] module, is defined as the areas that streams have recently occupied (in the last few years or less often decades), and would reasonably be expected to occupy again in the near future ... Field evidence that can be used to help define the CMZ [channel migration zone] includes unvegetated or sparsely vegetated side channels, wetlands, and signs of recent flooding such as wood debris suspended in branches or deposited outside the ordinary high water mark and large amounts of sediment deposition. The zone may have a significant shrub (e.g., vine maple, salmonberry) and/or hardwood (e.g., cottonwood, red alder, big-leaf maple) component, but few conifers. The water table is often near the surface and abandoned or active side channels are abundant."

There are several types of channel migration (e.g., see Richards, 1982). *Lateral migration* occurs when one channel bank erodes while the opposing bank accumulates deposited sediment, thereby causing the entire channel to move laterally. The focal point of lateral migration often is a meander bend. *Channel or chute cut-offs* develop when a river bend is abandoned in favor of a new, straighter, steeper channel that develops across the back of a river bar around which flow is diverted. *Channel avulsion* occurs when an upstream perturbation in the channel or floodplain causes the river to abruptly change course and move to a new location on the floodplain. Lateral migration can occur over long time periods, whereas avulsions occur rapidly and often are associated with large floods. Channel avulsions, for example, are the dominant channel-migration process at the proposed crossing site on the Tolt River (King County Surface Water Management Division, 1991, p. 14).

Regulatory prescriptions have addressed channel migration zones in several forest-practices watershed analyses. For example, a prescription for the South Fork Touchet Watershed Analysis stipulates a no-harvest area from the center of the active channel to the edge of the channel migration zone (WDNR, 1997). This prescription addresses the demonstrated links between road construction and timber harvest on channel banks, removal of tree-root strength holding the stream banks together, bank erosion, and channel migration into areas previously occupied by stream banks (WDNR, in preparation(a), Prescription RIP-LWD-1b). The identified resource concern in this example is the reduction in long-term recruitment sources of large woody debris, necessary for maintaining fish habitat, as a result of ongoing bank collapse and channel migration.

To my knowledge, there are no final or draft prescriptions regarding channel migration zones for any of the Watershed Administrative Units (WAUs) crossed by the proposed pipeline route.

Q. *What methods will be used to build stream crossings and install the pipeline?*

A. According to the pipeline application, most of the 293 proposed water crossings would be engineered by digging a trench through the channel, burying the pipeline, and refilling the trench. This is considered an invasive technique because the channel bed and water flow would be disrupted by construction activities. Approximately 83% of the proposed channel crossings (i.e., 242 crossings, excluding irrigation canals) would be trenched. The pipeline would be installed in the remaining 17% by utilizing existing bridges, burying the pipeline in roadfills with existing cross drains (e.g., culverts), and drilling holes through substrate beneath channel beds or irrigation canals. Hence, most of the crossings would be constructed with methods that have the greatest potential, relative to other pipeline crossing techniques, of disrupting the channel bed and impacting public resources.

The majority of the 242 proposed stream-channel crossings (77%) would be open- or wet- trenched (i.e., water still runs through the channel) and others would be dry-trenched (i.e., crossings are constructed when the channel bed is dry) (OPL, 1998, pp. 2.14-4 through 2.14-13). Open trenching employs several methods (e.g., running water through flumes or around barricades) for diverting water away from sections of the trench as they are excavated in increments from one channel bank to the other. The Columbia River would be crossed via horizontal directional drilling in bedrock beneath the channel bed.

The 242 proposed channel crossings include:

(1) 86 wet trench (36% of total);

(2) 100 open trench, either using diversion or flume techniques (41%); and,

(3) 56 dry trench (23%).

These numbers were calculated using Table 9.1-5 (OPL, 1998).

In general, trenches would be excavated to a depth of 5 feet, to “avoid exposure from [channel] scour” (OPL, 1998, p. 2.14-4, para. 4). The burial depth would be increased in channel beds with extensive scour, based on geotechnical analyses performed *after* application approval and before site construction. As discussed later in this testimony, calculating the depth to which scour occurs is problematic and varies substantially depending on sediment and hydraulic conditions of the local channel reach .

Therefore, the majority of stream crossings would be disturbed by trench-digging associated with pipeline installation, potentially impacting stability of the channel bed and impacting public resources (see answers to the following questions for details).

In my opinion, there is insufficient discussion and analysis of the alternatives to trench-building (e.g., constructing new bridges or overpasses). The application refers a number of times to construction cost:

> “Open cut trenching is proposed for crossing most streams because overall there would be minimal impacts to surrounding streamside habitat and it is the least expensive method” (OPL, 1998, p. 3.4-75, para. 6) ... “This crossing procedure was selected because it is a traditional pipeline construction technique, and the cheapest method.” (OPL 1998, p. 3.4-98, para. 1).

However, there is little discussion about alternatives to trench building in terms of their potential for reducing possible impacts to public resources. I would recommend that EFSEC require a field-based analysis of the crossing alternatives that involves more than construction costs and assumed minimal impact to public resources.

Q. How would the channel trenches be filled back in following pipeline installation and could this have an effect on channel-bed erosion (scour)?

A. Application section 2.14.3.1 indicates that the pipeline, following placement in the trench, would be covered to a depth of one foot with crushed stream-bed materials (or sand, if native materials were not suitable) to cushion the pipe. The rest of the open trench then would be back-filled with "clean gravels of a size similar to the original stream" (OPL, 1998, p. 2.14-6, para. 2) brought in from elsewhere (p. 3.4-99, para 1).

Yes, trench-refilling techniques could affect bedload transport and channel scour. The ability of channel flows to mobilize and transport sediment through a given channel reach is influenced significantly by the shapes, size distributions, densities, and packing of sediment (e.g., see Wiberg and Smith, 1987; Whiting and Dietrich, 1990; Wilcock, 1990; Wilcock et al., 1996; Buffington and Montgomery, 1997). [Sediment packing is the ratio of the volume of material and the volume of void spaces between sediment particles.] Hence, the type of material used to fill the trench could influence substantially the rate and depth of sediment mobility following pipeline installation. If the rate and depth of sediment mobility (i.e., leading to channel scour) were to increase as a result of pipeline construction, not only would downstream public resources be impacted by changes in the sediment-transport regime, but also the pipeline might be re-exposed to scour and potential damage.

There are several reasons why sediment mobility in the vicinity of the pipeline crossing likely could be modified:

(1) The armor layer at the surface of the channel bed could be eradicated in an approximately 30-foot-wide swath at the site, providing a greater potential for high-discharge flows to locally erode the bed surface and subsurface.

Gravel-bedded mountain streams, typical of Cascade drainages crossed by the proposed pipeline route, tend to have an armored bed (e.g., see King County Surface Water Management Division, 1991; Weyerhaeuser Co., 1993; Weyerhaeuser Co., 1995; Plum Creek Timber Co., 1997a, 1997b, 1997c; WDNR, 1998). The armored bed surface is composed of coarser sediment (e.g., larger gravels, cobbles) and the subsurface is composed of finer, more easily eroded sediment (e.g., smaller gravels, sand, silt). The armored layer commonly is packed (i.e., the cracks between larger sediment are filled with finer sediment), making the surface more resistant to erosion. When the armor layer is removed, the unconsolidated materials of the subsurface are susceptible to scour. Removing the armor layer, therefore, makes the bed surface more susceptible to erosion at lower-discharge flows.

Given that armor layers would be removed during trench work, the possibility exists for greater erosion in the 30-foot construction corridor following pipeline installation. Channel scour could affect both upstream and downstream aquatic habitat because of the dependence of one reach on the sediment-transport and hydraulic behavior of adjacent reaches.

It is not apparent in the pipeline application how the protective armor layer would be reconstructed. References are made to re-contouring the bed surface following installation (e.g., OPL, 1998, p. 2.14-6, para. 2), but there is no discussion of the loss of local, protective bed armor and its potential effects on channel scour and pipeline exposure.

(2) Off-site gravels used to back-fill the trench likely would have a different size distribution because of the requirement for clean gravels (OPL, 1998, p. 3.4-99, para. 1), thereby affecting the mobility of sediments piled in the trench.

The application proposes that clean gravels (i.e., those without many cobbles, sand, or silt) be used to minimize the potential for release of fine sediment to downstream reaches with sensitive aquatic habitat and water quality (OPL, 1998, p. 3.4-99, para 1). Depending on the source of gravel material, the trench could be filled with particles that are smaller, rounder, and more equal-sized (e.g., cleaned, glacially rounded, quarry gravels typically used for construction in the Snoqualmie and neighboring drainages). Smaller, rounder sediment would be more erodible than armored, less homogeneous, more angular materials characteristic of rivers (see discussion of Tolt River sediments, King Country Surface Water Management Division, 1991, pp. 6-10; Kirchner et al., 1990).

Therefore, I believe that the potential exists for increased bedload transport and channel scour during high-discharge events following stream-crossing construction and repair. Increased channel scour could influence substantially the potential for pipeline exposure and damage, as well as alterations to nearby upstream and downstream in-stream habitat. In my opinion, this is a substantial concern because the work area in most channels would average 30 feet wide (OPL, 1998, p. 2.14-5, para. 5) and would be most susceptible to erosion during seasonal high flows following pipeline installation.

Although the pipeline application makes a number of statements like the following:

"Construction methodologies used for the Cross Cascade Pipeline Project should produce no increase in bedload transport ..." (OPL, 1998, p. 3.4-100, para. 6),

such comments do not appear to be supported by any discussion of rationales, analyses, or data obtained in the field.

Furthermore, the scour screening analysis performed by WEST Consultants, Inc. for the pipeline project (see Appendix B-1, OPL, 1998) did not address the potential impacts, as described in the preceding paragraphs, of removing the bed armor during trench digging or back-filling the trench with a different mixture of sediment.

Hence, I would recommend that EFSEC require the applicant to address, in the pipeline application or FEIS, the potential disruptions of pipeline construction on the armoring process in streambeds, the potential effects on sediment transport and erosion of using off-site gravels, and the consequent impacts of both to public resources.

Q. *What was the purpose of the screening-level scour analysis performed for OPL? In your opinion, does this analysis adequately identify crossings with potential significant scour?*

A. The purpose of this analysis, performed by WEST Consultants, Inc. (OPL, 1998, Appendix B-1) was to identify channel crossings that would need further evaluation in the field for determining the initiation and depth of channel-bed scour.

WEST Consultants identified approximately 30 such crossings by assuming that the potential scour depth is on the order of 3 feet, and 7 crossings assuming a potential scour depth of 10 feet (their Table 1, p. 7). To obtain these estimates, they used an empirically based model (i.e., one that requires field or experimental data as input) with a number of assumptions regarding channel hydraulic conditions and sediment-transport parameters.

In my opinion and that expressed in the DEIS (p. 3-38, para. 1), this analysis is incomplete for several reasons. The first is that a critical final step is missing. That step would be to field-verify the model predictions of scour potential at all crossings. As with all empirically based models (e.g. those that require field or experimental data as input), the results are only as good as the data that go into running the model. In this case, a number of key assumptions were made about site parameters, and off-site data were used to calibrate the model. Hence, the possibility exists that scour-susceptible crossings were not identified adequately by the model. The consequences of inaccurately judging scour depths when positioning the pipeline, at any of the proposed crossings, could mean a damaged and leaking pipe, with downstream impacts to water quality and aquatic habitat.

The second reason is that the model does not apply to all channel types encountered along the proposed pipeline route. The DEIS also raises this valid point:

> "The generalized screening level approach accomplished to date by OPL would be useful in evaluating the scour potential of low gradient (1 to 2 percent) streams with respect to fluvial sediment transport processes. However, the scour potential of steeper gradient streams, including all of those within the Cascades, needs to be reevaluated to consider the high shear stresses applied to the beds of these streams. The scour evaluations also need to consider the effects of rapid gully advancement in steep disturbed streams, flow constrictions, log jams, debris flows, and headward migration resulting from stream degradation, all of which have been observed at or near proposed stream crossings." (p. 3-38, para. 1)

In other words, the analysis did not address all factors that potentially contribute to local channel scour. To my knowledge, no comprehensive model exists that accounts for key scour parameters. Hence, the presence and influence of these variables at any given channel crossing would have to be evaluated in the field.

The pipeline application (OPL, 1998) does not discuss either of these factors, even though they are identified in the DEIS.

Q. In your opinion, what additional information regarding trench back-filling and scour potential needs to be included in the application?

A. Given the potential for increased scour and resulting impacts to public resources, as described in the answer to a preceding question in this testimony, I believe that the applicant should specify trench-filling methods for each stream crossing and complete all site-specific scour analyses *prior* to a decision by EFSEC on the merits of the application. The pipeline application indicates that site-specific construction plans, including final analyses of scour potential, would be completed during the design and engineering phase of the project, which comes *after* the application-approval phase (e.g., OPL, 1998, p. 2.14-4, para. 4). Typically, site-specific analyses and construction plans in advance of approval decisions are required (e.g., by forest-practices applications and Hydraulic Project Approvals(HPAs)), so that the impacts of proposed activities on public resources can be fully evaluated.

If the detailed, geotechnical analyses of scour potential at stream crossings are to take place after application approval, the application at least should state how these analyses would be performed. The quality of obtained information varies greatly between a look-see approach and a systematic field analysis. The application does not include any examples of the field methods used to investigate scour, making it difficult to evaluate whether the appropriate set of information was considered.

In its current form, the application does not provide me with enough information about design and construction methods and materials to evaluate the relative degree of scour and resource impact in the 242 stream crossings proposed in the application.

Hence, I believe that OPL's application should state the following:

(1) source and sediment properties of trench replacement materials;

(2) replacement methods (i.e., how materials are packed in the trench and how the surface is re-contoured);

(3) methods to be used in the field for locating the "maximum scour depth";

(4) results of more detailed bedload-transport and scour analyses; and,

(5) how crossings would be monitored to identify and correct scour problems.

In my opinion, site-specific scour analyses also should include the following:

(1) measurements of channel-bed depth, given that it would be difficult to excavate to the prescribed average depth of 5 feet if the unconsolidated sediment layer is less than 5 feet deep;

(2) construction-plan alternatives if impenetrable layers (e.g., bedrock) are encountered such that the obligatory 2 feet of trench fill above the pipeline cannot be achieved (e.g., horizontal directional drilling);

(3) potential impacts of not using the original excavated material as back-fill in the trench (e.g., see comments in the preceding question of this

testimony);

(4) effects of channel migration on scouring new channels and exposing the pipeline in areas other than the identified low-gradient crossings; steeper-gradient streams also migrate, although to a lesser extent because they typically are more confined within valley bottoms;

(5) potential changes in near-term hydraulic and sediment-transport dynamics upstream of proposed crossings that might affect channel conditions at the pipeline crossing; and,

(6) mitigation for those changes in the near- and long- term (e.g., how the company would correct scour problems, and replace in-channel pipeline segments that become damaged).

With the exception of channel migration, none of these factors is discussed in the application or supporting documents. Although channel migration (i.e., lateral instability) was mentioned in the scour analysis performed by WEST Consultants, Inc. (OPL, 1988, Appendix B-1, scour study, p.1), it was not treated explicitly in their exercise to compute scour-critical crossings.

Q. What methods would be used to install the pipeline in floodplains with active channel migration and could this have an effect on channel-bed erosion (scour)?

A. According to the pipeline application (OPL, 1998, p. 3.3-55, para. 1), the pipeline would be buried below “maximum scour depth” across the full width of the floodplain and coated with concrete or other materials to protect the pipe from bed scour and flotation following potential exposure. The design and installation techniques would be the same as those described previously in this testimony for open-trench methods.

The main threat to pipelines buried across in active channel migration zones is that the main channel(s) could move laterally to incise new channels in the floodplain surface, or reoccupy old channels. Channel lateral migration and avulsion, hence, would increase the potential for stream erosion through floodplain deposits, with consequent exposure of the pipeline to scouring and possible damage. New channels created across the floodplain portions of the trench line would be subject to increased scour, as described previously in this testimony.

Recommendations regarding what additional information pertaining to channel migration zones should be included in the application are stated later in this testimony.

Q. In your opinion, do the pipeline application and DEIS provide an adequate analysis of potential channel migration and associated scour in the proposed water crossings?

A. In my opinion, the pipeline application and supporting documents do not provide a complete analysis of channel-migration potential and possible impacts to the pipeline and public resources resulting from channel migration. Furthermore, the documents do not address the converse, that is, the potential for pipeline construction to provoke channel migration due to changes in the topography of the floodplain surface promoted by trench building. Reasons are given below.

The application and DEIS list a number of potential impacts to the pipeline associated with channel migration (e.g., see DEIS, p. 3-33 to 3-34), but these are not developed and discussed further. Site-specific analyses of channel migration are left to the design and engineering phase of the project, which would occur *after* approval of the application. Given the potential for pipeline exposure and damage at any of a number of channel crossings, associated with lateral migration and avulsion, I believe that site-specific analyses in the field should be completed *prior* to application approval, so that there is adequate information about migration behavior on which to base a risk assessment and effective mitigation measures.

The pipeline application and associated analyses do not address potential channel-changing events at several key crossings, as described in the following paragraphs. Furthermore, these crossings have not been identified as critical in the scour analysis (WEST Consultants, Inc., Appendix 2; see OPL, 1998, Appendix B-1) and/or the channel sensitivity analysis (OPL, 1998, Table 3.3-6).

For example, the application does not address the potential for slope failures to partially obstruct channel flow and cause lateral channel migration or avulsion. The Griffin Creek crossing (Crossing No. 28, Dames & Moore, 1998, p. 12) potentially is jeopardized by an active deep-seated failure, the toe of which is being undermined by the creek (Weyerhaeuser, 1995, Prescriptions, p. 10). In addition to posing hazards to pipeline integrity on the hillslope (see written testimony regarding mass wasting, Susan

Shaw, WDNR), the potential exists for landslide materials to enter the channel, thereby obstructing the flow and causing the channel to shift toward the opposing bank.

The Griffin Creek crossing was identified in the scour analysis (WEST Consultants, Inc., 1997, Appendix 2; see OPL, 1998, Appendix B-1) as being less sensitive to potential channel scour, thus requiring no further study. If the company were to follow these recommendations and not perform a thorough field analysis, a number of scenarios are possible, including: (1) the landslide toe is undermined by the creek or by pipeline construction, or by both; (2) the landslide debris entering the creek causes flow to be deflected across the valley bottom; (3) the channel moves in the direction of flow deflection; (4) the pipeline trench is subjected to erosion associated with bank erosion and scour due to channel migration; (5) the pipeline is exposed and possibly damaged; and, (6) downstream aquatic habitat and water quality are impacted by sediment (and potentially petroleum products) released by the landslide, floodplain incision, and channel scour. Such an occurrence would be contrary to the forest-practices rules (e.g., WAC 222-16-050(d)) and regulatory prescriptions requiring that operations minimize potential activation of the landslide in order to prevent or avoid sediment delivery to vulnerable fish habitat (Weyerhaeuser, 1995, Prescriptions section, pp. 10-11).

In addition, the river crossings identified in Table 3.3-7 (OPL, 1998, p. 3.3-52) as having 100-year floodplains (i.e., those valley bottoms in which channel shifting typically occurs through lateral migration and avulsions) are not accompanied by any discussion in the text regarding how channel migration would be accommodated or crossing methods mitigated, with the exception of the proposed drilling beneath the Columbia River. The principal mitigation for rivers with large floodplains is to bury the pipeline at maximum scour depth. As discussed in the answer to the following question, however, locating the maximum depth is problematic and relies on site-specific geotechnical analyses. The application does not discuss the potential for channel avulsions, associated with upstream changes in sediment-transport or hydraulic conditions, to alter the maximum depth as determined from present-day channel-bed geometries. Nor does the application address what mitigation measures might be taken to reduce the threat of channel avulsions to pipeline exposure. Hence, the discussion of these specific sites appears to be inadequate for basing an evaluation regarding the ability of the buried pipeline to withstand channel migrations and potential exposure to damage.

Therefore, I believe that all channel crossings should be evaluated in the field, to ensure that key relevant factors are considered.

Q. What additional information regarding channel migration zones needs to be included in the application?

A. In my opinion, the following channel-migration factors need to be addressed in the pipeline application. The current analysis is incomplete with regard to several key factors known to govern channel migration. A more thorough analysis could pinpoint sites not suitable for pipeline installation, resulting in the need to realign the pipeline. For this reason and others previously mentioned, I believe that site analyses should be completed prior to approval of the application.

An example of this scenario would be the Griffin Creek crossing (Crossing No. 28, Dames & Moore, 1998, p. 12) where the potential exists not only for construction-related reactivation of a deep-seated failure (see mass wasting section of this written testimony, Susan Shaw, WDNR), but for landslide debris to obstruct channel flow, causing local channel scour and migration. This would be considered a violation of the Washington Forest Practices Act (WAC 222-24-020(6); Road Location) and a violation of a watershed-analysis prescription (Weyerhaeuser Co., 1997, Prescriptions section, p. 10-11).

The following section describes which analyses of channel-migration factors are incomplete or missing, and the rationales for why I think that they should be included:

(1) As stated previously, each channel crossing should be analyzed thoroughly in the field. If the company were to rely on the recommendations of the scour study regarding which crossings should receive further study in the field (OPL, 1998, Appendix B-1, see WEST Consultants, Inc., 1997, Appendix 2), several critical crossings potentially would not be analyzed adequately to account for actual channel migration and scour potential (e.g., see the Griffin Creek example given in the answer to the preceding question of this testimony).

In that regard, the analysis would benefit substantially from reviewing available site-specific studies that were not mentioned in the application and supporting documents. For example, channel-migration behavior and rates over much of the past century have been analyzed by King County Surface Water Management Division (1991) in the vicinity of the Tolt River crossing (see reaches B and C in their report). Potential hillslope and channel-migration issues at the Griffin Creek crossing are addressed by Weyerhaeuser Company (1997).

(2) The pipeline application indicates that the primary mitigation in areas with identified channel migration zones would be to bury the pipeline below “maximum scour depth” across the full width of floodplains (OPL, 1998, p.3.3-55, para. 1).

The application does not define the meaning of “maximum scour depth”. The scour depth might vary significantly across the channel and floodplain because of the topographic variability (i.e., low points associated with channels and high points associated with river bars and floodplain depositional surfaces). Hence, finding the maximum scour depth would require determining the scour depth for each low point and high point on the proposed trench transect, and then selecting the deepest. In addition, maximum scour depths could vary significantly over time. Hence, basing estimates of maximum scour depths on currently observable scour features likely would not account for situations (e.g., extreme magnitude floods) in which the scour depths could increase dramatically.

The application should state how the maximum scour depth would be determined. The purpose of the screening-level scour analysis (OPL, 1998, Appendix B-1) was to identify potential crossings that would be susceptible to scour, not to derive the scour depth. The application gives no indication how such analyses would be performed in the field. The difference between a reconnaissance-level field review and systematic determinations of maximum scour depth at successive points along the proposed pipeline crossing could mean the difference between correctly and incorrectly identifying the potential for channel migrations or avulsions to expose and damage the pipeline.

(3) The application and supporting analyses do not address key factors considered important in an assessment of channel migration and scour. They might be mentioned as concerns in the DEIS (e.g., see pp. 3-33 to 3-34), but they are not addressed explicitly in terms of their potential impact on proposed crossing sites and potential mitigation. They include upstream and downstream changes in channel hydraulics and material input (e.g., sediment, wood) associated with:

a) landslides and bank erosion;

b) changes in channel planform (i.e., if the next meander bend upstream changes shape or location, the channel likely could shift laterally at the crossing site);

c) changes in local base-level (i.e., lowering or raising the channel gradient downstream due to a number of forcing factors, could alter the gradient at the crossing site, which would affect the ability of the stream to erode or deposit sediment); and

d) changes in upstream river discharge and slope that might affect the rates of flow and sediment-transport through the crossing reach.

Any of these factors, alone or in concert, could affect rates and magnitudes of channel erosion and lateral migration. For example, King County Surface Water Management Division (1991) identifies aspects of each of these parameters that have promoted rapid and significant changes in channel-migration rates at the Tolt River proposed crossing during the mid and latter parts of this century (e.g., average rates of 14.7 feet per year, peaking during the 1989-1991 period with rates on the order of 55 feet per year during major channel avulsions).

(4) The application does not state what would be done with large woody debris (e.g., logs) encountered by trenching.

Large woody debris plays a fundamental role in anchoring sediment bars within the valley bottom. Research (e.g., Abbe and Montgomery, 1996) suggests that log jams and single old-growth conifer logs act as flow obstructions that collect sediment, allowing channel bars to form and grow over time. Wood also creates channel and floodplain habitat diversity, including low-energy, backwater environments conducive to fish usage (Naiman et al., 1992).

Removing large woody debris located on floodplain surfaces or buried beneath them might reduce the potential for sediment deposition, flow reduction, and stabilization of channel bars (Smith et al., 1993). Loss of floodplain structure could enhance local rates of channel migration (e.g., WDNR, in preparation(a)).

Hence, mitigation measures should address how large woody debris would be treated during construction.

(5) There appears to be no discussion of the potential for construction-related changes to channel planform, nor of their potential for impacting public resources.

The proposal application should discuss the potential for construction activities to change the channel and floodplain topography in the vicinity of the trench. Altering the size and location of material deposits, overflow channels, and other features could affect the rates and extent of future channel migration and scour.

For example, creating low points in a gravel-bar or floodplain surface (e.g., depressions in the trench line) could encourage the channel to split or avulse during high discharges when water overflows these areas. Stream capture in this manner has played a key role in the rapid and extensive channel avulsions that have occurred at the proposed Tolt River crossing (see King County Surface Water Management Division, 1991, pp. 14-17).

Altering the topography of the channel and floodplain surfaces could affect public resources. This would include such factors as the location, size, and amount of main-channel and side-channel fish habitat, and loss or creation of off-channel and side-channel fish habitat (Bisson et al., 1992).

Q. Could any of the proposed construction activities at channel crossings result in a violation of the forest practices act and associated regulations?

A. Road construction on channel side slopes, across channels, or in floodplains would be considered a violation of the forest-practices regulations if it resulted in:

(1) destabilizing slopes and channel banks (WAC 222-24-020(6));

(2) excessive erosion and/or soil movement, promoting "damage to public resources" (WAC 222-24-030(7));

(3) sediment delivery from road surfaces directly into the channel, due to inadequate or nonfunctional cross drains (WAC 222-24-025(7));

(4) unstable soils (e.g., inadequately revegetated) in the streambank staging areas for trench construction (WAC 222-24-030(4)); or,

(5) dumping of construction debris (e.g., slash, spoils) into the channel (WAC 222-24-030(5)).

Issue (1), and how such violations could occur due to the proposed pipeline construction as currently described (OPL, 1998), are addressed in written testimony regarding mass wasting (Susan Shaw, WDNR). Issues (2), (3), and (5) are addressed in written testimony of Ronn Schuttie (WDNR). Issue (4) and others related to vegetation management, riparian management zones, and streambank stability are discussed in written testimony by Todd Bohle (WDNR).

Regulatory prescriptions resulting from forest-practices watershed analysis also are potentially violated. One example is the prescription prohibiting road construction and reconstruction at the Griffin Creek crossing (Weyerhaeuser Company, 1997, Prescription section, p. 10-11).

Pipeline construction in the channel and channel migration zones, and its potential impacts on public resources should be subject to the laws governing HPAs and water-quality and shorelines issues.

Q. In your opinion, do the DEIS and application provide a complete assessment of risk factors and potential impacts of pipeline construction on channel crossings and public resources?

A. In my opinion, the risk and impact assessments of pipeline construction through channels are incomplete. Some of the incomplete aspects of the analysis have been addressed in previous comments in this testimony (e.g., those related to channel scour and lateral migration).

While the application and DEIS list a number of physical channel factors that could be impacted by pipeline construction, they typically are not analyzed in any further detail. In general, the list of potential problems tends to be followed by a one-sentence explanation, without the benefit of scientific or technical analysis, as to why they would not be significant concerns.

In my judgment, these statements do not substitute for analyses, and there is no way of knowing whether or not they are accurate statements. Hence, it is not possible for me to evaluate the true risks and impacts of this project on public resources. For example:

Regarding turbidity and sedimentation:

(1) "The extent of increased turbidity will depend on both the existing channel condition and the selected construction methodology. Typically the effects will be short lived and will disappear once construction ceases and restoration measures are employed." (OPL, 1998, p. 3.3-29, para. 6)

This statement is not supported by further discussion or analysis indicating that the effects will be short-lived. Given the potential for channel-bed scour to be enhanced by trench-digging and pipeline installation, as described previously in this testimony, it is not clear that this statement is true.

(2) "Pipeline construction will include temporary erosion control measures (see Section 2.10 Surface Water Runoff) which will minimize erosion and sedimentation impacts to surface waters. Disturbances to the channel from excavation will temporarily impact stream bank and bed integrity, increasing vulnerability to erosion and releasing entrapped fine grained sediments. These effects, however, will generally be localized, and will diminish in the downstream direction." (OPL, 1998, p. 3.3-32, para. 1)

This statement is not supported by further discussion or analysis indicating that disturbances would be temporary and localized. As previously discussed with regard to potential loss of channel-bed armor and increase in channel lateral migration, the effects of construction could persist, particularly where channels are subject to chronic lateral migration, periodic avulsions, and/or impacts from landslides and debris flows. Shifting the channel across its floodplain, due to loss of bank integrity during construction or changes in the hydraulic regime, could affect the rates and locations of sediment erosion and deposition in the vicinity of the pipeline crossing, thereby potentially impacting public resources and the integrity of the pipeline.

(3) "Construction methodologies used for the Cross Cascade Pipeline Project should produce no increases in bedload transport, but will release varying amounts of suspended sediment." (OPL, 1998, p. 3.4-100, para. 6)

This statement is not supported by further discussion or analysis. As discussed previously in this testimony, potential construction-related disruptions of the hillslope (e.g., active mass-wasting sites), banks, channel bars, and floodplain surfaces could lead to channel scour, channel migration, and bedload transport. The Griffin Creek crossing, as noted previously in this testimony, is one construction site in which all of these events likely could occur.

Regarding channel-bed scour:

(4) “If the pipeline were exposed by scour at river and stream crossings potential damage to the pipeline might occur. However, the burial depth at river and stream crossings will be sufficient to prevent exposure.” (OPL, 1998, p. 3.3-33, para. 5)

As discussed previously in this testimony, the screening-level scour analysis was performed to indicate crossings in need of further study (see OPL, 1998, Appendix B-1, WEST Consultants, Inc., 1997, Appendix 2). Analyses of scour potential and appropriate burial depth would be made for some or all crossings in this category, leaving others potentially without adequate analysis. For example, one crossing identified as requiring no further study has a high potential for stream scour and migration (Griffin Creek; see previous comments in this testimony, regarding the landslide and channel behavior at this crossing).

Regarding floodplains:

(5) “The pipeline construction will not impact flood magnitudes and floodplains because of the relatively small area impacted within a given watershed, and because there will be no physical obstructions to flow ... Impacts to the flooding and floodplains during operation are also expected to be minimal and nonsignificant, since the pipeline will be buried and pipeline facilities will be small in area and located outside of designated floodplains.”

These statements are not supported by further discussion or analysis. For example, the potential for construction-related disturbance and alteration of the floodplain surface is not mentioned. As previously discussed in this testimony, changes in surface features (e.g., loss of large woody debris, blocking of surface and subsurface drainages with the trench or pipe itself, changing the type and/or size distribution of sediment during trench back-filling) could affect flow and sediment-transport characteristics. As previously discussed in this testimony, such changes could influence rates of sediment deposition and erosion, lateral migration and bank stability, and formation of off-channel or side-channel habitat.

Regarding impacts of construction on public resources:

(6) “The trenches will be dug during low water flows with the only impact occurring in the 30 foot wide construction corridor across the streambed.”

This statement is not supported by further discussion or analysis. Potential impacts to upstream and downstream reaches include changing the channel planform (i.e., channel curvature and position with respect to the valley walls) as a result of construction-related changes to the form and position of the channel at the crossing site (e.g., causing the channel to migrate). Such changes could affect the sediment-transport and hydraulic regimes of upstream and downstream reaches, with consequent potential impacts to public resources.

(7) “Potential impacts to aquatic resources would be limited to the construction phase of the project.” (OPL, 1998, 3.4-128, para. 2).

This statement is not supported by further discussion or analysis. See comments in (1), (2), (3), (4), and (6) above.

(8) "Open cut trenching is proposed for crossing most streams because overall there would be minimal impacts to surrounding streamside habitat and it is the least expensive construction method" (OPL, 1998, p. 3.4-75, para. 6) ... "This crossing procedure was selected because it is a traditional pipeline construction technique, and the cheapest method." (OPL, 1998, p. 3.4-98, para. 1).

The statement regarding minimal impact to habitat is not supported by any analysis.

These single statements do not, in my professional judgment, substitute for a complete analysis of cause and effect (i.e., environmental consequences). As stated, they really are hypotheses rather than analytical results. Hence, I do not believe that a full risk and impact assessment has been completed.

Furthermore, the applicant states that some of the potential impacts will be evaluated in greater detail *following* application approval. However, OPL gives no indication of what is included in the critical analyses necessary to assure that the above statements are true.

Q. In your opinion, do the DEIS and application clearly indicate how proposed stream-crossing methods would minimize or prevent damage to public resources?

A. No. As near as I can deduce from reading these documents, the expected impacts largely are summarized in single sentences, without the benefit of complete analyses or stated rationale (see comments in the answer to the preceding question). In addition, there appears to be little discussion regarding how the selected mitigation measures would minimize or prevent damage to public resources. In general, I believe that insufficient information and analysis has been presented in the application and DEIS to evaluate the likely impacts of pipeline construction and maintenance on fish habitat and water quality.

The rationale, assumptions, and interpretations used in calculating impact potential (e.g., see OPL, 1998, p. 3.4-108 through 3.4-111, and Table 3.4-8) are not presented with enough detail, if at all, to evaluate their comprehensiveness and appropriateness.

For example, the stream-gradient variable used in Table 3.4-111 pertains to depositional rate of fine sediments; a lower value indicates greater deposition potential. However, there is no similar variable corresponding to sediment transport and erosion. Steeper-gradient streams along the pipeline route have a relatively high potential for debris flows and other erosional events that can impact substantially the downstream public resources (e.g., see Weyerhaeuser Co., 1997; Plum Creek Timber Co., in preparation (a,b,c)). Hence, it seems that this variable should be weighted by the potential for streams in the higher gradient class to transport landslide debris (i.e., coarse and fine sediment) to sensitive habitat and, in some cases, eradicate downstream habitat.

Given that these impact sensitivity ratings would be used in the field by the construction manager to determine the appropriateness of the proposed trenching method

(OPL, 1998, p. 3.3-30, para. 3), I believe they should be clearly described and supported with scientific rationale. The rating scheme also should be tested in the field to verify its accuracy. A substantial amount of construction decisions regarding resource impacts appear to be riding on numbers that, in my judgment, have not been adequately explained, supported, and tested.

Q. Are streams with the highest rating for potential impact sensitivities crossed with non-invasive techniques?

A. No. In many cases, open-trench methods are proposed for streams with the highest ratings for potential impact to fish habitat.

For the sake of evaluation, I considered all stream crossings in Table 3.4-9 (Impact Potential of Waterway Crossings on Fish Habitat, p. 3.4-114 through 3.4-123, OPL, 1998) with a sensitivity rating greater than 7 as having the highest potential for impact to fish habitat. The scale appears to run from 0 to 10. As such, it appears that the majority of streams with high potential impacts would be crossed by open-trench techniques that involve digging up the channel bed and banks in a 30-foot-wide swath.

Specifically, only 3 of the 19 most potentially sensitive crossings would be constructed with non-invasive techniques (e.g., bridges, existing road fills with cross drains, horizontal directional drilling). These are the Snoqualmie River (Crossing No. 11), Peoples Creek (Crossing No. 14), and the Columbia River (Crossing No. 223).

Hence, I believe that construction alternatives for the other sensitive reaches should be discussed in greater detail, so that a better understanding exists of the chosen construction method for each site.

Q. Have any mitigation measures been identified that address expected impacts related to stream crossings? If yes, identify these mitigation measures.

A. Yes, some generic mitigation measures have been identified (see p. 1.4 -3 (Construction at Water Crossings), p.1.4- 14, 15 (Watercourse Crossing Procedures), p. 1.4-16 (Floods and Floodplains Mitigation Procedures), and p. 1.4- 29, 30 (Stream Crossings)). It is difficult, however, to evaluate the applicability of these measures to any one crossing without additional site information (e.g., site construction plans and geotechnical analyses of channel conditions and processes).

For example, as mentioned previously in this testimony, it is not clear how the company would go about determining maximum scour depth and channel-migration potential (e.g., p. 1.4-16). The requirement for burying the pipeline to "maximum scour depth" sounds reasonable. What that translates to on the ground, however, is not described, nor are there any assurances that maximum scour depth can be located with confidence in the larger, lower-gradient streams.

Hence, I believe that the mitigation measures should be addressed in greater detail. Where not self-evident, discussions of mitigation measures should include:

(1) proposed methods (e.g., locating scour depth, determining extent of channel migration, re-contouring surfaces following trench back-fill);

(2) potential impact on channel processes and public resources of installing mitigation measures (e.g., blasting, installing riprap, using off-site gravels as trench fill);

(3) exceptions to the generic measures (e.g., mitigation alternatives when stream-crossing construction cannot be contained to a 30-foot-wide swath, mitigation alternatives when the pipe cannot be buried at least 2 feet below scour depth in the channel bottom); and,

(4) monitoring of mitigation effectiveness and changes in channel conditions that could jeopardize the pipeline and/or public resources.

Without such information, it is difficult to analyze the effectiveness of mitigation efforts in minimizing impacts to stream channels and vulnerable public resources.

Q. *Based on the preceding testimony, what are your summary recommendations?*

A. The WDNR does not administer any RCWs or WACs related specifically to operations in stream channels, unless they pertain to forest-practices activities (i.e., road construction through channels or timber harvest within the banks of channels). Hence, the following recommendations are based on the potential for pipeline construction in stream crossings to impact channel processes and in-stream public resources. I recommend that EFSEC consider the following additions or modifications to the application (see detailed discussions of each item in the preceding testimony for rationale and supporting information):

(1) The applicant complies with laws governing Hydraulic Permit Approvals (HPAs) and water-quality issues for stream-crossing construction, so that the specific site construction plans and impacts to public resources can be fully evaluated.

(2) The applicant complies with all WACs related to road construction and timber harvest in stream channels.

(3) The application or DEIS addresses alternatives to open trenching in all crossings for which some form of trenching has been proposed, particularly those identified as having a high potential impact on channel conditions and public resources. The DEIS does not appear to address alternative pipeline construction methods.

(4) The application includes a complete, field-verified analysis of the potential for channel scour associated with pipeline construction at each stream crossing. The current analysis is incomplete (i.e., not fully verified), and the potential for channel scour is difficult to assess without specific information, for each proposed trench crossing, regarding channel form and processes, hydraulic conditions, sediment properties (including disturbance of the armor layer at the channel-bed surface), construction design and methods, materials used for trench back-fill, and continued site use (e.g., whether crossings would be forded during pipeline ground inspections and maintenance, creating further disturbances). Until such information is known, it is difficult at best to evaluate the appropriateness of the proposed crossing methods and the potential impact to in-stream public resources.

(5) The application defines methods for determining maximum scour depths in channels, given that the successful pipeline crossing hinges on burying the pipe below the "maximum scour depth". It is difficult to evaluate the ability of pipeline construction to accommodate potential channel scour without knowing how the applicant proposes to measure scour depth.

(6) The application includes a complete, field-verified analysis of the potential for channel migration and avulsion, at each proposed crossing, to impact the buried pipeline and in-stream public resources. At least for those sites possessing substantial channel-migration zones (e.g., OPL, 1998, Table 3.3-7), analyses should be completed to determine the maximum scour depth, potential future migration behavior, and potential for exposing the pipeline and affecting in-stream public resources. It is difficult to evaluate the proposed crossing methods and impacts to public resources in channel migration zones without this information.

(7) The application and DEIS provide complete analyses of potential impacts on channel processes and public resources, to replace unsubstantiated statements in the current versions of the documents. Previous comments in this testimony listed a number of such statements that were given as fact with no supporting arguments or data. They include comments regarding the short-lived effect of increased turbidity, temporary and localized channel disturbances associated with trench-

digging, no increases in bedload transport, pipeline protection from scour, and potential impacts to aquatic resources being limited to the construction phase of the project (see citations given previously in this testimony). In my opinion, these statements need to be supported with further rationale, discussion, and analyses; otherwise, it is not clear on what information they are based.

List of Footnotes:

[1] The Timber/Fish/Wildlife (T/F/W) Agreement, completed in 1987, is a fluid agreement between cooperating parties to work together to resolve issues related to forest protection and management outside the litigation arena. Cooperating parties include the state agencies (WDNR, WDOE, WDFW), federal agencies, timber industry, tribal governments, and environmental groups. Policy decisions are made by T/F/W's Policy Committee. Research is funded via T/F/W's Cooperative Monitoring, Evaluation, and Research Committee (CMER) with funds provided by the state legislature.

[2] All stream channels, lakes, and ponds in the state are categorized in a typing system, as per WAC 222-16-030. These waters are shown on a stream classification map (i.e., WDNR's HydroLayer) that reflects information supplied by the WDNR, WDOE, WDFW, and affected Indian tribes. The water typing system is based on beneficial uses, one of which is fish. Under the Washington Forest Practices definitions (WAC 222-16-030), Types 1, 2, and 3 waters contain anadromous fish (i.e., those that use sea and river habitat during portions of their life cycles) and resident fish. Types 4 and 5 waters do not support fish. Type 1 waters also include all waters inventoried as "shorelines of the state" under chapter 90.58 RCW.

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I certify and declare under penalty of perjury under the laws of the state of Washington that the foregoing is true and correct to the best of my knowledge and belief.

SIGNED AT ________________________, Washington this ________day of February, 1999.

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Susan C. Shaw, Ph.D.